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MAPPING OF GROUNDWATER QUALITY OF A COASTAL WATERSHED USING GIS

K. EZHISAIVALLABI & S. POONGOTHAI

Department of Civil Engineering, Annamalai University, Annamalai Nagar, Chidambaram, Tamil Nadu, India

ABSTRACT

Coastal watersheds differ from others by their unique features, including proximity to the ocean, weather and rainfall patterns, subsurface features, and land covers. Land use changes and competing needs for valuable water and land resources are especially more distinctive to such watersheds. Coastal groundwater aquifers are negatively affected by land use changes, with associated reduction in recharge and increase in chemical use, and are subjected to the threat of saltwater intrusion. Water quality of receiving waters, such as estuaries, bays, and near shore waters, are negatively impacted by stream chemical, biological, and sediment pollutants. Limited water resources and concerns regarding water quality necessitate the need for best management practices. Hence, there is need for a better understanding of the various physical, chemical, and biological processes involved. The purpose of the present study is to estimate the groundwater quality in a coastal watershed and thematically represent it using GIS for understanding of the present scenario at a glance. Geographic information system (GIS) is an efficient and effective tool in solving problems where spatial data are important. Therefore, it is widely used for assessment of water quality and developing solutions for water resources related problems. In this study an attempt is made to estimate the ground water quality of Adappa watershed, which is a coastal watershed located on the tail end of Tamilnadu and existing both in Nagappatinam and Thiruvarur districts, India. More than 30 samples of the ground water are collected from the bore wells which were aerially distributed all over 55 villages of the study area. The samples were analyzed using standard procedures in the laboratory. Watershed map has been collected and digitized using ArcGIS 9.3. The database obtained from water quality analysis is used as attribute database for preparation of thematic maps showing distribution of various water quality parameters. The results of the water quality analysis were presented in the form of maps which can be used for better understanding of the present water quality scenario of the study area. The spatial variations of water quality parameters were discussed.

KEYWORDS: Coastal Watershed, Ground Water, Water Quality Parameters, Spatial Mapping, GIS

INTRODUCTION

The Indian coastal watershed has a privileged combination of valuable natural resources and distinctive landscape. About 7500km long Indian coastline varies from open sea to semi closed coastal waters and shows significant diversity in environmental and demographic features. The skewed growth in anthropogenic activities, in the coastal areas has generated tremendous stress upon natural ecosystems and created problems for their proper management. In addition, the Indian coastline needs to be protected from natural hazards, such as beach erosion, sea level rise, storms, cyclones etc. Attempts to overcome this problem have been made through large investments in coastal area throughout India.

Suitability of water for various uses depends on type and concentration of dissolved minerals and groundwater has more mineral composition than surface water (Mirribasi et al., 2008). Groundwater is the major source of water for domestic, agricultural and industrial purposes in many countries. India accounts for 2.2% of the global land and 4% of the world water resources and has 16% of the world’s population. It is estimated that approximately one third of the world’s population use groundwater for drinking (Nickson et al. 2005). The quality of groundwater is constantly changing in

response to daily, seasonal and climatic factors. Continuous monitoring of water quality parameters is highly crucial because a change in the quality of water has far reaching consequences in terms of its effects on man and biota. For example, overexploitation of ground water in coastal regions may result in sea water ingress and consequent increase in salinity of ground water and also excessive use of fertilizers and pesticides in agriculture and improper disposal of urban/industrial waste can cause contamination of ground water resources. Geochemical processes have been shown to have an influence on the prevalence of anthropogenic and natural contaminants in coastal environments worldwide (Toda et al. 2002). The chemical character of any groundwater determines its quality and utilization. The quality is a function of the physical, chemical, and biological parameters, and could be subjective, since it depends on a particular intended use.

Remote Sensing and GIS can be used as a powerful tool for developing solutions for water resources problems for assessing water quality, determining water availability, preventing flooding, understanding the natural environment, and managing water resources on a local or regional scale. The present study aims to utilize remote sensing and a geographic information system (GIS) for mapping of groundwater status of the study area.

STUDY AREA

The study area, Adappa watershed(4B1A2b) lies between latitudes 10°16’N-10°44’N and longitudes 79°30’E-79°52’E Figure 1 and the study area is situated in the southern part of Tamilnadu, With an area of 695.79 sq.km.

Geology of the Study Area

Geologically, the area is underlain by a wide range of Rocks of Marine-Paleo-Tidal Flat Deposits and Fluvial -Flood basin Deposits and Marine-Paleo-Tidal Flat Deposits.

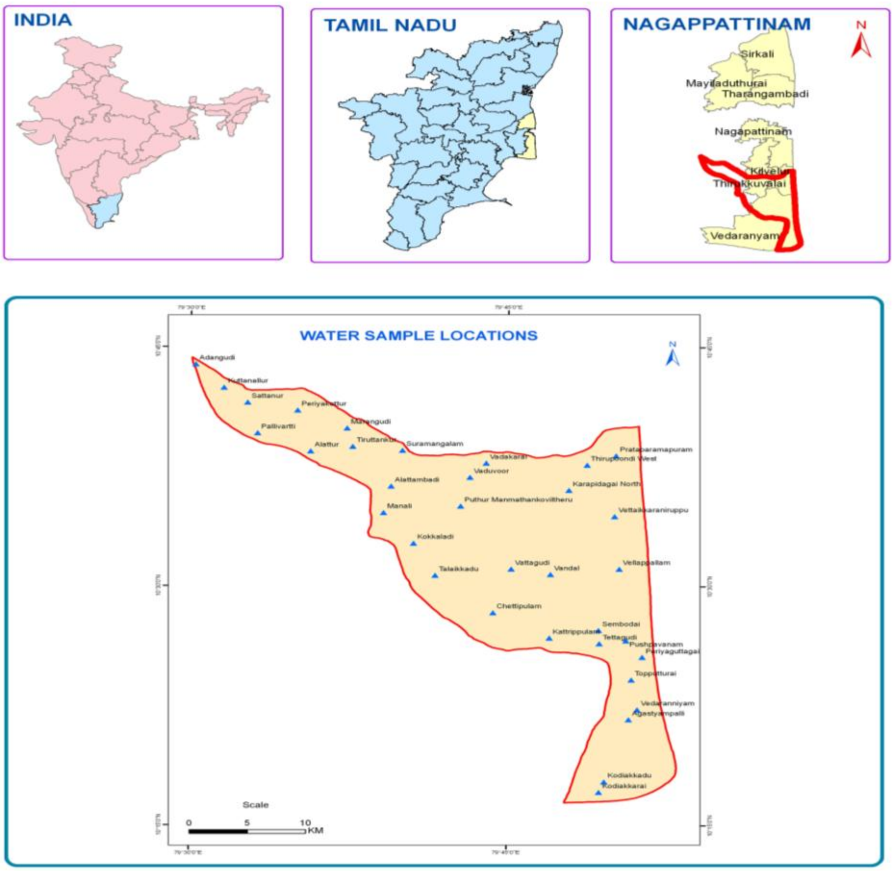

Figure 1: Sampling Locations of the Study Area

MATERIALS & METHODS

The ground water samples are collected manually from the bore wells which were approximately equally distributed all over 55 villages of adappa watershed. More than 30 samples were collected and analyzed during the Pre (June) and post (Feb.) monsoon of 2012. The list of samples collected is given in Table 1. The groundwater samples are analyzed for various water quality parameters such as pH, total dissolved solids, total hardness, calcium, magnesium, chloride, and sulphate concentrations.

The techniques and methods followed for the collection, preservation, analysis, and interpretation are those given by BIS (1998). GPS is used to map the location of each sampling borehole; and finally, the results of each parameters analyzed were added to the concerned boreholes. ArcGIS 9.3, was used to find out the spatio-temporal behavior of the groundwater quality parameters. The various thematic layers on hardness, pH, and ionic concentrations were prepared using a spatial interpolation technique.

RESULTS AND DISCUSSIONS

The analytical results for all the physico-chemical and irrigational quality parameters for the pre-monsoon and post monsoon groundwater samples from the study area are presented in Table 1. The spatially distributed maps were prepared for all the parameters using GIS Tools, the results were discussed as below.

pH

The hydrogen ion concentration (pH) in the post monsoon water samples varies from 6.92 to 8.60 with an average of 7.76. In pre monsoon it varies from 6.75 to 7.52 with an average of 7.14. As per the BIS (10500:1991) standards all the samples of both the season falls within the recommended limit (6.5 to 8.5) are indicating its alkaline nature except in Vedaranyam during post monsoon figure 2.

Electrical Conductivity

Electrical Conductivity is the measure of mineral content, was found varying from 110µS/cm to 7500µS/cm in Post-monsoon and 110µS/cm to 6600µS/cm in Pre-monsoon figure 3. Variation in conductivity of water may due to the geological features of the sites or due to drains carrying domestic waste water.

Calcium

Calcium occurs in water naturally. Calcium cannot be found alone in nature. The calcium was found to be in the range of 6.43 mg/lit to 644 mg/ lit in Post-monsoon and 63.7 mg/lit to 838.2mg/ lit in Pre-monsoon figure 4. 85% of the area falls beyond the permissible limits during pre-monsoon season. In post-monsoon becomes 39% due to dilutions.

Magnesium

Magnesium content of the ground water samples ranges from 8.71 to 387 mg/lit in Post-monsoon and 35 to 469 mg/lit in Pre-monsoon figure 5. In post monsoon, the highest concentration of manganese was recorded at Puttur with a value of 387 mg/l. For maximum samples manganese recorded higher values above the desirable limits set by BIS standards of >100 mg/l. in the pre-monsoon. The concentration of magnesium was found to be within the permissible limits in the villages like Vadakarai, Thirupoondi, Karappidagai north.

Sulphate

The Sulphate content in all the ground water samples are below the limit prescribed by BIS in both the seasons

Post and Pre-monsoon, except sample number 12 (Kokkaladi) in pre-monsoon. BIS has prescribed desirable limit of sulphate is 200 mg/lit and permissible limit in the absence of alternate source is 400 mg/lit figure 6.

Chloride

Chloride concentration ranges from 11.2 to 915 ppm and 60 to 1910 ppm during post and pre monsoon seasons respectively. The high chloride concentration is noticed in 5 locations in the pre-monsoon season. High concentration of chloride produces salty taste in drinking water and thus water becomes objectionable for drinking Figure 7.

Total Dissolved Salts

Total Dissolved Salts content of the ground water samples ranges from 80 to2900mg/lit in Post-monsoon and 70 to 4290 mg/lit in Pre-monsoon figure 8. The TDS more than 3000 mg/l concentration not only unfit for irrigation, but also deteriorate the quality of soil, which intern effect the yield of agriculture production (Davis and DeWiest 1966).

Total Hardness

Hardness is very important parameter in decreasing the toxic effect of poisonous element. Highest concentration of total hardness is found in the villages Tiruttankur, Manali and Kodiyakkarai south in pre-monsoon season. It is due to rocks bearing salts of Calcium and Magnesium. In all other villages the concentration of total hardness was found to be lying between 90 to 600 mg/l Figure 9 in both seasons.

Nitrate

The nitrate concentration is found to be in the range of 1 to 8.3 mg/lit in Post-monsoon and 2 to 14 mg/lit in Pre-monsoon figure 10. It is within the desirable limit. BIS prescribed desirable limit of nitrate is 45 mg/lit. Presence of nitrate in water indicates the final stage of mineralization (Nema et. al., 1984).

Bicarbonate

Bicarbonate ion is varies from 1 to 9 ppm and 2.4 to 10.2 ppm in post and pre monsoon seasons respectively figure 11. It is within the desirable limit. BIS prescribed desirable limit of bicarbonate is 50ppm.

Potassium

Natural waters normally contain low concentration of Potassium. High values of potassium should be looked upon with some suspicion as these may indicate pollution. Neither BIS nor any other organization lay down any limits for potassium content in drinking water (Srivastava, 2007). The potassium content in ground water have been found in the range of 1.96 mg/lit to 150 mg/lit in Post-monsoon and 3.91mg/lit to 324.2 mg/lit in Pre-monsoon figure 12.

Table 1: Physico Chemical Parameters of GW of Study Area in Premonsoon and Postmonsoon

Id	Location	Premonsoon									Postmonsoon								
		pH	TDS	Ca	K	HCO_3	Cl	SO4	NO3	TH	pH	TDS	Ca	K	HCO_3	Cl	SO4	NO3	TH
1	Kuttanallur	6.8	1040	326	210.3	4.2	320	45	8.2	260	7.14	1088	340	150	3	200	25	6	200
2	Adangudi	6.75	510	319.7	28	6	100	15	12	280	7.09	293.8	412	3.66	4	80	10	8	190
3	Sattanur	7.04	1040	468.5	32.6	7.2	160	75	8.5	140	7.29	925.6	312	17	5	90	40	5	100
4	Periyakottur	6.84	825	299.5	26.2	6	320	39	4.5	380	7.16	514.8	352	16.4	4	344	27	3.5	290
5	Pallivartti	7.14	1202	360.8	276.4	4.4	500	21	5	360	7.67	576	46	100.1	3.1	56	21	1	480
6	Marangudi	7.08	2405	475.4	6.4	8.4	1080	126	6	240	7.3	915	175.4	72	3	700	96	4	490
7	Alattur	6.94	1560	838.2	64.2	4.4	130	99	8.2	520	6.92	863.9	444	1.96	1.2	732	72	5.2	400
8	Tiruttankur	6.65	1950	642.5	25.6	6.4	780	39	6.8	620	7.2	1280	54 2	140	2.3	540	31	4.1	550
9	Alattambadi	6.56	2795	412.5	16.4	5.6	1180	135	14	600	7.1	1950	460	12	1.6	900	79	7	540
10	Suramangalam	7.45	422	148.2	16.7	4	170	39	9.2	260	7.4	140	422	11	2	150	30	6.2	210
11	Manali	6.89	2795	287.2	227.4	10.2	1200	150	12.2	640	7.3	2900	120	117	5.3	915	110	8.1	500
12	Kokkaladi	6.72	4290	612.2	28.6	9	1800	225	12.5	580	7.1	2100	187	17	9	600	170	8.3	430
13	Talaikkadu	6.76	1040	215.4	16.8	6	340	51	6.5	460	7.4	720	412	120	5.3	860	39	4	360
14	Chettipulam	7.08	273	609.2	113.9	3.4	60	114	14	368	7.2	840	115	64	2.2	40	75	7.2	290
15	Kattrippulam	7.15	630	198.8	195.6	5	180	21	6.2	400	7.2	400	298	150	4	110	16	4	320
16	Vattagudi	7.18	468	218.6	86.5	3.6	160	57	9.2	180	7.1	440	140	26	1.6	90	41	5.2	120
17	Sembodai	7.13	448	176.9	120.5	4.4	140	15	4.8	280	7.82	711	12	7.2	3.4	460	12	3	290
18	Prataparamapuram	7.15	760	696.2	89.5	7.4	160	45	6.5	140	6.99	2503	472	Nil	5.2	137	36	4	90
19	Vettaikkaraniruppu	7.17	468	211.5	79.9	4.4	140	15	5.2	280	7.22	1197	60.7	19.51	2	11	11	4	190
20	Vellappallam	7.09	3445	289.6	324.2	3.4	1910	195	12	488	7.01	643	56.8	0.8	1	550	140	7.2	390
21	Pushpavanam	6.98	442	140.1	28.3	2.4	102	15	4.2	200	7.2	400	110.1	17	1.4	90	11	3	140
22	Tettagudi	7.14	728	493.2	48.3	5	170	51	12	420	7.57	331	6	3.1	3	115	32	7	340
23	Peryaguttagai	7.08	624	333.8	45.9	5	160	21	5	272	7.1	360	117	17	3	122	16	4	210
24	Topputturai	7.32	351	163.7	85.1	8	120	15	2	220	7.2	226	57.2	17.2	4	112	9	1.1	160
25	Vedaranniyam	6.89	682	632.4	23.2	4	270	42	4.8	240	8.6	273	40	15.4	4.1	119	30	3.1	140
26	Kodiyakkadu	7.32	663	303.2	185.1	5.6	160	60	11	228	8.13	971	6.43	22.5	3	118	41	6	170
27	Agastyampalli	6.98	1267	447.9	294.1	5.8	540	78	8.2	260	8.37	400	57	13.2	4	211	64	4	210
28	Kodiyakkarai south	7.22	357	423.8	182.7	6	490	93	9.6	760	7.41	890	22.89	99.6	1	228	67	5.1	510
29	Vandal	7.52	318	63.7	91.7	3.6	60	6	4.8	128	7.1	450	47	40	1.7	40	4	3	90
30	Valakkarai	7.3	306	95	12.99	5	92	16	8.2	472	7.3	410	95	12.99	1	62	10	4	320
31	Puttur	6.91	1424	644	3.91	4.6	628	18	6.4	458	6.91	1424	644	3.91	3.1	418	12	4.1	360
32	Vadugur	7.11	137	80	34.6	5.3	60	42	5.3	226	7.11	136.5	80	Nil	4.2	42	32	4.2	140
33	Karappidagai north	7.15	70	27.48	67.3	6.2	60	32	7.5	468	7.1	80	27.48	Nil	3.2	40	25	4.7	350
34	Thirupoondi	7.52	338	119	45.5	4.8	160	52	6.4	437	7.43	1943	81.1	13.7	3	48	41	5	340

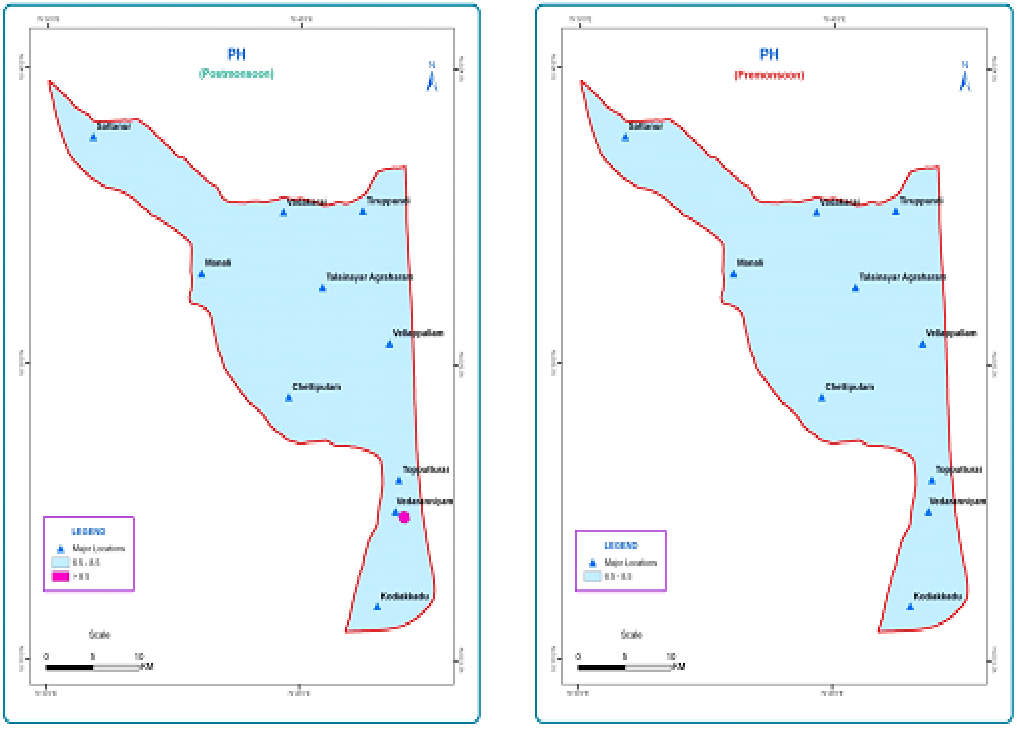

Figure 2: Spatial Distributions of pH (Post and Pre- Monsoon – 2012)

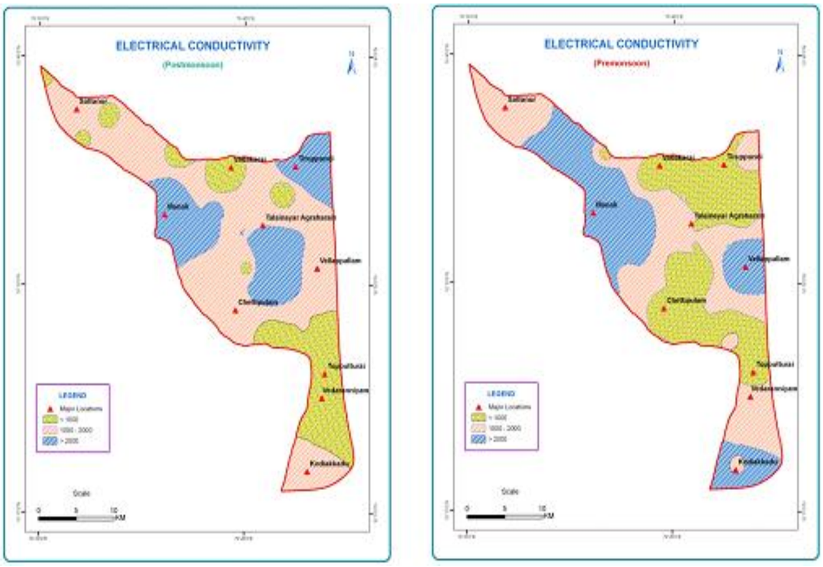

Figure 3: Spatial Distribution of Ec (Post and Pre- Monsoon – 2012)

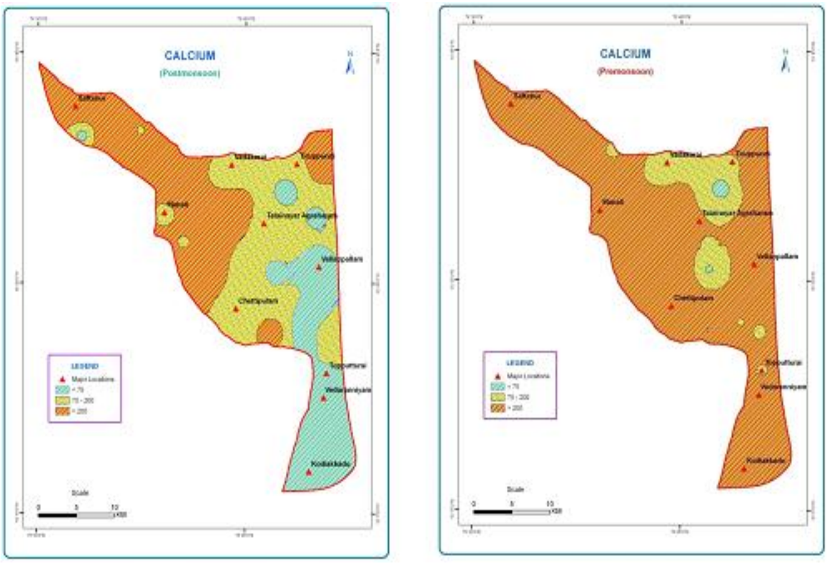

Figure 4: Spatial Distribution of Ca (Post and Pre- Monsoon – 2012)

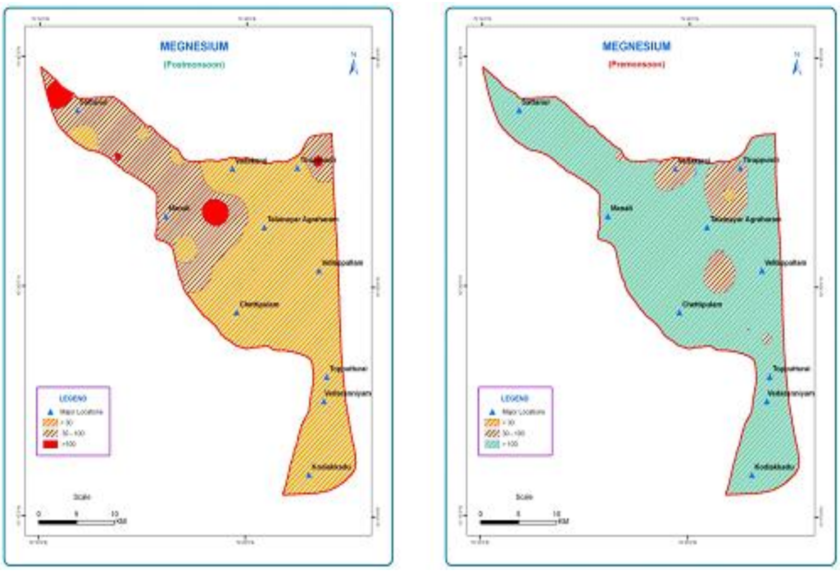

Figure 5: Spatial Distribution of Mg ((Post and Pre- Monsoon – 2012))

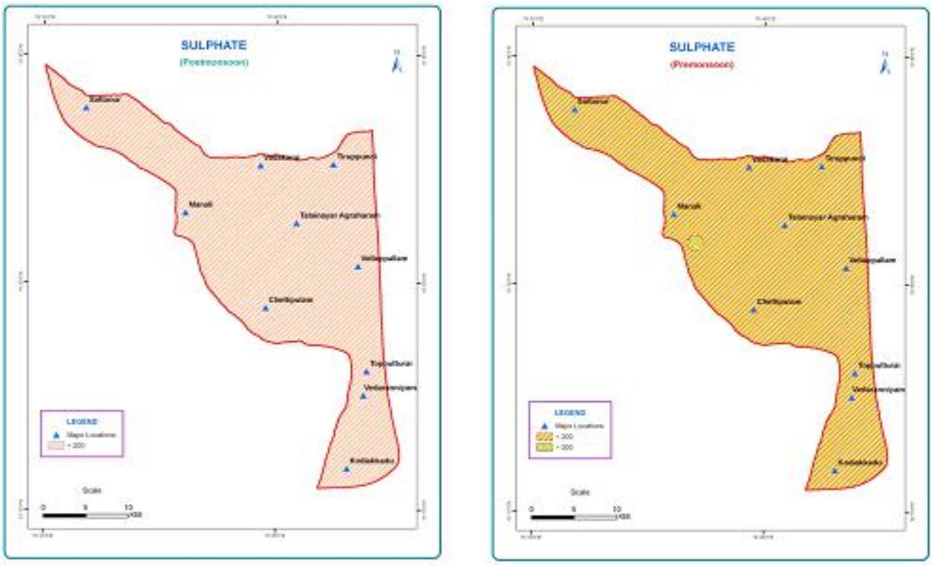

Figure 6: Spatial Distribution of SO_4 (Post and Pre- Monsoon – 2012)

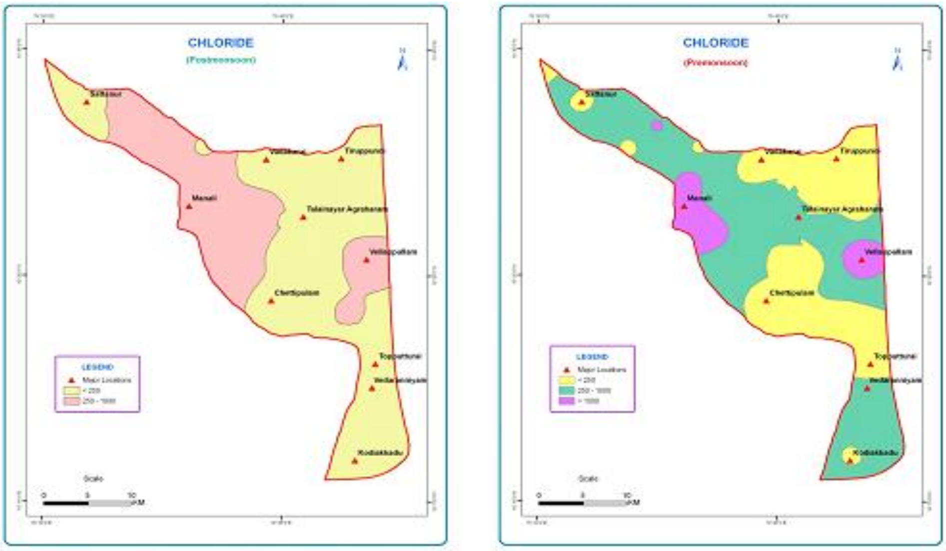

Figure 7: Spatial Distribution of Cl (Post and Pre-Monsoon – 2012)

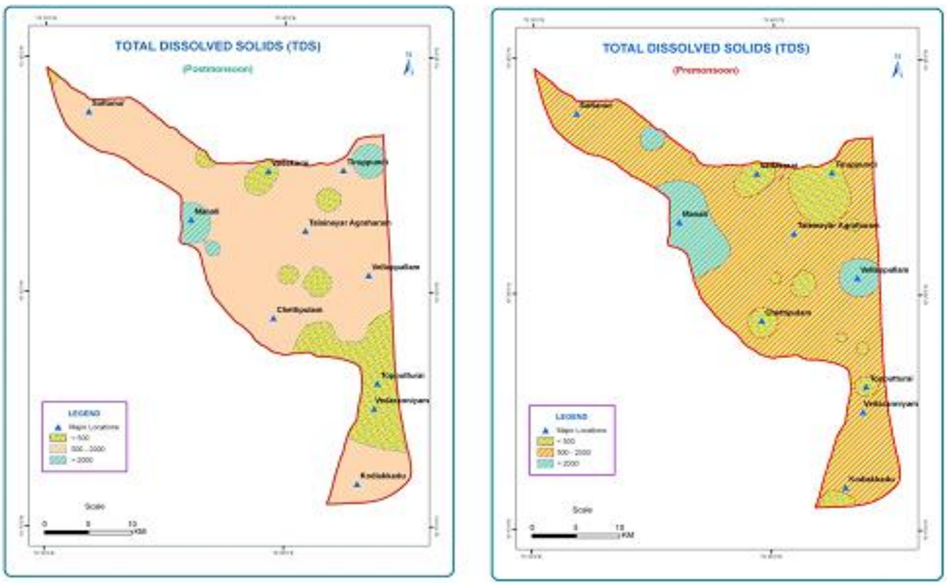

Figure 8: Spatial Distribution of TDS (Post and Pre-Monsoon – 2012)

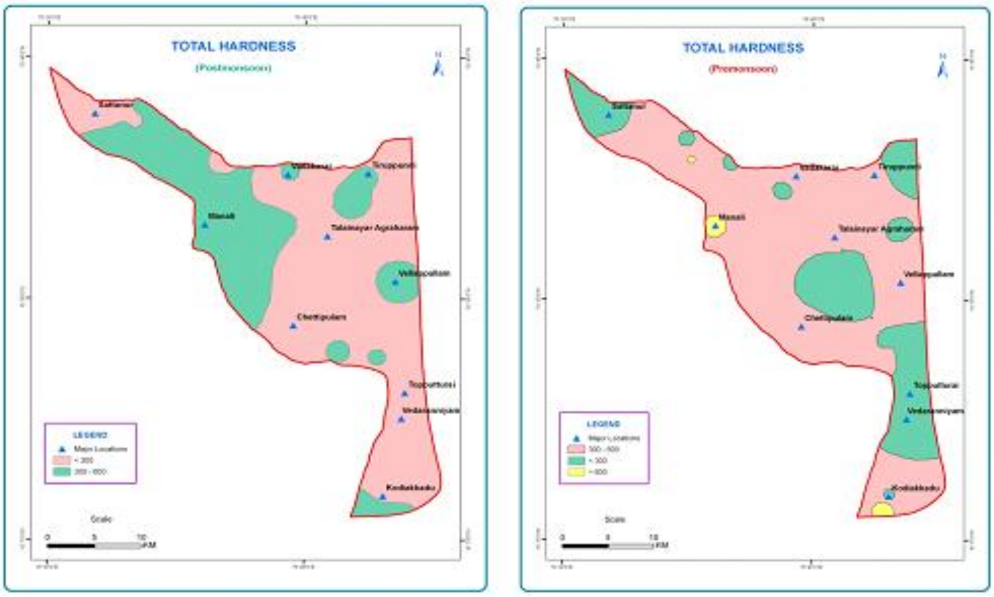

Figure 9: Spatial Distribution of TH (Post and Pre-Monsoon – 2012)

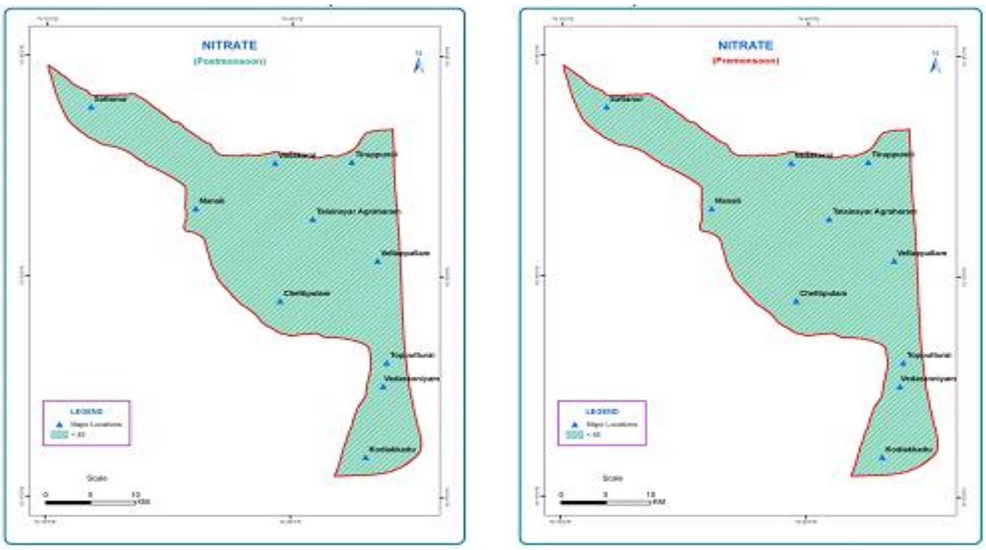

Figure 10: Spatial Distribution of NO_3 (Post and Pre-Monsoon – 2012)

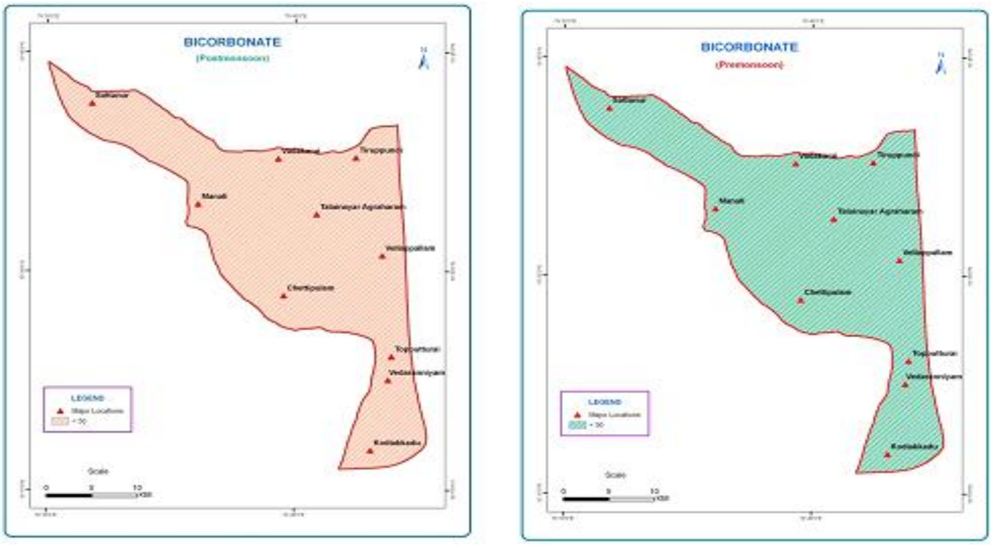

Figure 11: Spatial Distribution of HCO_3 (Post and Pre-Monsoon – 2012)

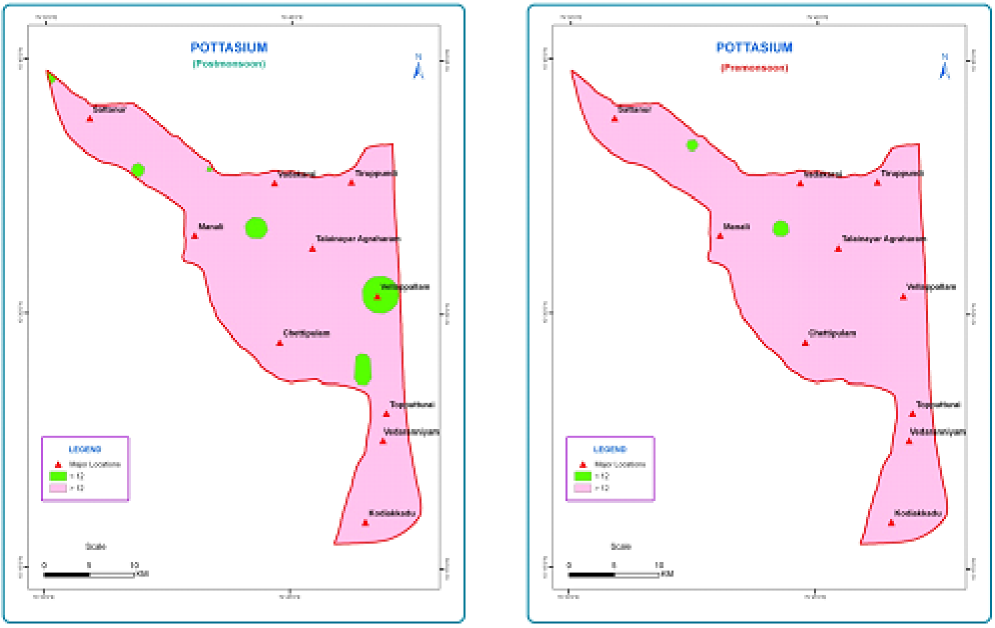

Figure 12: Spatial Distribution of K (Post and Pre-Monsoon – 2012)

CONCLUSIONS

The groundwater in the investigated area shows limited seasonal variations in quality. The final output has been given in the thematic representation of ground water quality. The analysis suggests that the groundwater of the area needs some degree of treatment before consumption. Better water quality was found in the Post-monsoon season than that of Pre-monsoon season, because of groundwater recharging due to rains. The study helps us to understand the quality of the water as well as to develop suitable management practices to protect the ground water resources.

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